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AN/BQR-7/DT-276 HYDROPHONE FAILURE MODE ANALYSIS.(U)
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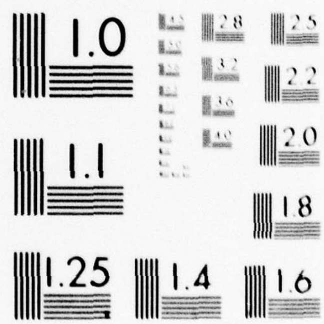

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LEVEL II

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TECHNICAL MEMORANDUM

AN/BQR-7/DT-276

HYDROPHONE FAILURE MODE ANALYSIS

Submitted to:

Commander, Naval Ship Systems Command
Department of the Navy
Washington, D.C. 20360

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19 January 1968

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AN/BQR-7/DT-276

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ABSTRACT

As part of the Transducer Replacement Criteria Task (3B) of Contract N00024-67-C-1168, Failure Mode Analyses were conducted by TRACOR on six defective DT-276/BQR-7 hydrophones removed from the USS PLUNGER (SSN 595) in Summer 1967. Results of the analyses indicate that the hydrophone failures occurred in two steps. Initially, the hydrophone cable began to hose when its watertight integrity failed. The hosing subsequently permitted moisture to enter the cable sleeve portion of the hydrophone, causing unsatisfactory electrical characteristics.

TABLE OF CONTENTS

1. INTRODUCTION

In September 1967, the Puget Sound Naval Shipyard removed 156 DT-276/BQR-7 hydrophones from the USS PLUNGER (SSN 595). Six of these hydrophones were sent to TRACOR's Rockville Laboratories for Failure Mode Analysis under Task 3B of Contract N00024-67-C-1168.

The hydrophones (A-20, A-82, A-86, A-93, A-143 and C-884) were received at TRACOR 15 November 1967. A very short length of the connecting cable was provided with each hydrophone. Electrical and mechanical tests were applied to each element beginning with close visual inspection of the hydrophones as received and ending with close visual inspection of the dissected elements.

2. DISCUSSION

2.1 TEST PROGRAM

2.1.1 Introduction

There were eight tests performed:

a. Visual Inspection

b. Piezoelectric Activity (Squeeze Test)

c. Insulation Resistance

d. Capacitance and Dissipation Factor

e. Vector Impedance/Admittance Locus Plot

f. Surface Dye Penetration

g. High Pressure Dye Penetration (Including Insulation Resistance Tests at Pressure)

h. Dissection and Inspection.

2.1.2 Instrumentation

The following equipments were used in the nondestructive tests:

a. Impedance Bridge
   General Radio Type 1650A

b. Complex Impedance/Admittance Meter
   Dranetz Model 100C with 100-PA-1001A plug-in unit

c. Electronic Counter
   Hewlett-Packard Model 5212A

d. Oscillator
   Hewlett-Packard Model 200CD

e. X-Y Recorder
   Honeywell Type 320

f. Megohmmeter
   General Radio Type 1862-C

2.2 RESULTS

2.2.1 Visual Inspection of all units in as received condition revealed no indications of malfunction. Shaking C-884 revealed that it was approximately half full of water.

2.2.2 Piezoelectric Activity (Squeeze) Tests were run as a qualitative test of hydrophone condition. All of the hydrophones, with the exception of C-884 showed a response.

2.2.3 Insulation Resistance Tests showed considerably different readings from those taken immediately after the removal of the hydrophones from the ship.

Unit A-82 read 280 megohms between the black and white leads, compared to readings of 40 to 70 megohms for the other hydrophones. In the case of hydrophone C-884, which was half full of water, no megger reading was possible. Although the insulation resistance between the two conductors of A-86 was within acceptable limits, the insulation resistance from the black and white leads respectively to shield was 40 to 100 megohms compared to 35 K to 75 K megohms for the other A-series hydrophones, thus indicating wet insulation. In the case of A-20, resistance between the black and white leads was below an acceptable limit while the resistance between each of these leads and shield was much greater than required. Later destructive tests showed that moisture was present in the base of the Metal Cable Sleeve in which the cable was potted.

2.2.4 Capacitance and Dissipation Measurements

Hydrophones A-20, A-86, A-93 and A-143 measured a capacitance slightly below the factory specified minimum value of 0.054 uF and dissipation factors less than the maximum allowable 3.5 percent. Hydrophone A-82 measured a capacitance of 0.0075 uF and a dissipation factor of 39 percent. It was found that the cable of this hydrophone was intermittent as well as wet. Hydrophone C-884 measured a capacitance of 0.003 uF and a dissipation factor of 38 percent. This hydrophone was half full of water.

2.2.5 Vector Impedance/Admittance Locus Plots

Complex impedance and/or admittance locus measurements were carried out on each element. A comparison of locus plots from each hydrophone allowed judgement to be made as to mechanical and electrical condition. In the case of A-93, it was obvious from the admittance locus plot that its active element was cracked or that glue joints had failed. The impedance locus of A-82 exhibited a very large clamped resistance indicating the possibility of a poor solder joint or other poor connection. The absence of an impedance locus on C-884 indicated a short circuit. All of the above faults were later confirmed by destructive tests.

2.2.6 Surface Dye Penetration Tests

Surface Dye Penetration Tests clearly indicated those areas on the hydrophone boot which had been patched. In one instance (A-82) there were five obviously patched areas on the

sides of the element. The patches were about 3/4 inch in diameter, roughly circular, and filled with a rubber material significantly different in texture from the surrounding area. Although this material appeared more porous, careful inspection of several of the areas revealed no through-holes. Dissection of these potentially "leaky" areas did not reveal signs of the fluorescent dye.

2.2.7 High Pressure Dye Penetration Tests

High Pressure Dye Penetration Tests were carried out on only two elements (A-82 and A-93). The shorter lengths of connecting cable provided with the other hydrophones prevented running this test on these units. Both elements were exposed to a hydrostatic pressure of 285 psig for five cyclic durations of 5 to 7 minutes each. After the fifth cycle, the elements were left for one hour at 285 psig. Inspection under Ultra Violet Light before and during boot dissection did not reveal water penetration into or through the boot wall. Both megohmmeter and capacitance measurements were carried out on hydrophone A-93 during its pressure cycling as well as during its sustained hydrostatic pressure test. No significant change in either insulation resistance, capacitance or dissipation factor was noted. Similar electrical tests were not run on A-82 due to its intermittent cable.

2.2.8 Dissection and Inspection of Units

Refer to Fig. 1.

2.2.8.1 A-20

Two patched areas were evident on the hydrophone cover but there was no evidence of water seepage through the boot. The silvering on the outside of the ceramic pulled away during boot removal. The cable sleeve showed definite evidence of water seepage along the potting compound/cable sleeve interface.

The cable shield was in fair to good condition. Hosing appears to have occurred along the inner conductors and not along the shield.

2.2.8.2 A-82

Intermittent cable connection could be made by lifting up and pushing down on the cable stub. At least 5 patched areas were evident in the boot. Careful slicing of all patched areas indicated no through-holes. Neoprene boot was very nonuniform, indicating that the unit had been off-center in the mold allowing a ratio of 3:1 in the thickness of the neoprene boot on opposite sides of the unit. The shield was in poor condition. Solder joints at the cable sleeve were in very poor condition; i.e., hardly attached to the prongs.

2.2.8.3 A-86

With the end cap removed, there was no sign of water seepage at cable sleeve or along the connecting cable. The neoprene molding was irregular. Except for low, but still acceptable capacity, the element appeared to be satisfactory.

2.2.8.4 A-93

Two patched areas were investigated and indicated no water seepage. The neoprene boot was not well bonded to the lower half of the hydrophone. The glue joint between ceramic cylinders was found unbonded when cross-sectioned. The cable sleeve was corroded externally and internally. Soldering of the leads is suspect since the inner leads easily detached with a minimum of damage to the leads.

2.2.8.5 A-143

The inside surface of the hydrophone was clean and dry, however, there were definite signs of corrosion on the cable sleeve and indications of water seepage in the cable.

2.2.8.6 C-884

C-884 had a very uniform boot with a clean, unmarred, surface finish and clean fillets on the top and bottom. The boot bonding was good except in the area of the lower inactive ceramic end cap. The unit was half full of water. The cable sleeve was very badly corroded as was the connecting cable shield. The entire unit showed the effects of water.

3. SUMMARY AND CONCLUSIONS

3.1 SUMMARY

The Failure Mode Analysis revealed the following problems associated with the six hydrophones.

a. Patched areas and clamp marks were found on the five "A" serial hydrophone boots, probably caused by unsatisfactory mold release and re-patching.

b. On all six hydrophones, the silvering separated from the ceramic before separating from the neoprene. Only on one half of hydrophone C-884 did the bond between the neoprene and the silvering separate before the bond between the silvering and the ceramic.

c. On two hydrophones the rubber covering was not concentric with the ceramic cylinders. In both cases, one side of the hydrophone had about three times the rubber thickness of the other side. This decreases the mechanical reliability and degrades the azimuthal uniformity.

d. On one hydrophone, the active ceramic sections were not bonded to each other when inspected.

e. On several hydrophones, the inactive ceramic end caps were not bonded to the cylinders.

f. On most hydrophones, the rubber was not bonded to the inactive end caps. This, while not significant acoustically, somewhat degrades the reliability of the system by making an otherwise insignificant abrasion a cause for failure.

g. Two hydrophones had poor soldering on the internal connections. The wire had broken away from the solder connection with little or no damage to the wire lead.

h. Several hydrophones had poor or no bonds between the cable sleeve and the inactive ceramic end caps.

i. In most cases the potting compound did not adhere to the steel walls of the cable sleeve or to the two fill holes. Both the walls and the sides of the fill holes were clearly rusted.

It should be noted that these problems are primarily associated with the A-series hydrophones and that the C-series hydrophone evidenced a considerable improvement in quality and appearance. The fact that only a single C-series hydrophone was available for examination prevents further generalization.

The measurements made at TRACOR (see Table 1) differ from the Puget Sound Naval Shipyard results. All hydrophones except A-86 and the shorted C-884 measured insulation resistance on the order of 2000 times the prior measurements in the black-to-shield and white-to-shield combinations. The black-to-white measurement generally increased by considerably less than an order of magnitude. All capacitance readings are lower by a few percent except A-82 which was considerably lower and C-884 which read essentially open. All the dissipation factors have decreased significantly. This is particularly true of the shield-related combinations. The measurement differences can be explained assuming substantial drying has occurred during the interval between Puget Sound measurements (September 1967) and TRACOR measurements (November 1967).

3.2 CONCLUSION

The failure mode associated with most of the hydrophones involved hosing within the cable, into the cable sleeve, and a track along the wall of the sleeve and out of the epoxy filler holes. The detail deficiencies noted do not indicate corresponding deficiencies in the basic mechanical design. The mechanical design of the hydrophone is considered to be very good.

4. RECOMMENDATIONS

Water-tight integrity of the hydrophone may be improved through the incorporation of several small changes. These are:

a. Forcing more potting compound into the sleeve and possibly into the cable itself under pressure would improve the life of the hydrophone. The potting compound on most units stopped short of entering the cable itself and covered only the two individual stripped leads.

b. Investigation of priming/potting combinations to improve the bonds between the cable sleeve, potting material, and connecting cable elements.

c. Provision of a water-block, integral with the hydrophone, and located sufficiently outboard of the hydrophone to allow recabling.

The last recommendation covering water-tight integrity comes from information from various Navy sources indicating that if a DT-276 hydrophone assembly (cable connector, cable, and hydrophone) is found to be below acceptable specification, recabling is employed under certain conditions. To determine if recabling is to be used, the cable is cut-off approximately 6 inches from the hydrophone and the hydrophone is tested. If the results of the retest are satisfactory, then a new cable and connector are remolded to the old hydrophone and the assembly is installed.

In items a through i of 3.1, problems were noted which point out areas of possible improvement of manufacturing techniques and procedures. Areas noted were:

a. Ceramic silvering

b. Cable encapsulation

c. Solder connections

d. Neoprene molding

e. Neoprene/ceramic bond

It should be noted that these analyses were performed on five A-series hydrophones with serial numbers 143 and under and on one C-series hydrophone. If similar Failure Mode Analyses performed on more recently manufactured hydrophones revealed similar results, then some review of the indicated problem areas could be considered.

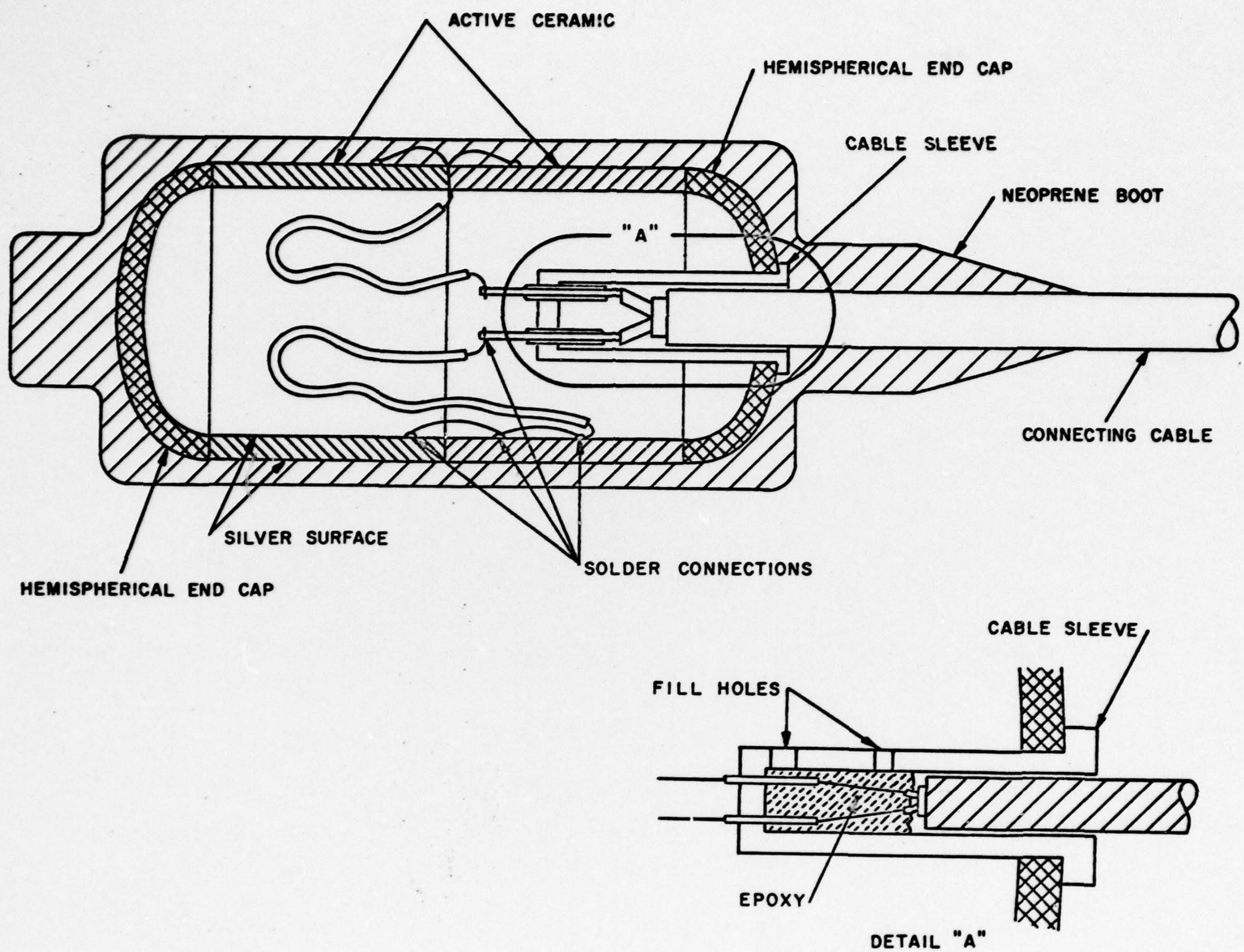

FIG. 1 DT-276/BQR-7 HYDROPHONE

TABLE I

DT-276/BQR-7 HYDROPHONE DATA

S/N	LOC.	CONDITION	CAP (µF)	DISIP (%)	INSULATION RESISTANCE (MEGOHMS) B/W	B/S	W/S
A-20	41B	PUGET SOUND					
		AIR			12		
		WATER			15		
		CUT (AIR)*	.0533	2.9	8	20	20
		TRACOR					
		AIR	.0507	1.9	40	40,000	35,000
A-82	33C	PUGET SOUND					
		AIR					
		WATER					
		CUT (AIR)*	.0528	50	250	40	30
		TRACOR					
		AIR	.0075	39	280	60,000	55,000
A-86	48A	PUGET SOUND					
		AIR			20		
		WATER			15		
		CUT (AIR)*	.0539	2.25	45	45	10
		TRACOR					
		AIR	.0517	2	50	40	100
A-93	44C	PUGET SOUND					
		AIR			10		
		WET			13		
		CUT(AIR)*	.0532	3.55	45	40	40
		TRACOR					
		AIR	.0505	1.8	55	75,000	76,000
A-143	33B	PUGET SOUND					
		AIR			23		
		WET			32		
		CUT (AIR)*	.0526	2.65	15	25	25
		TRACOR					
		AIR	.0505	1.9	74	45,000	40,000
C-884	39C	PUGET SOUND					
		AIR	0		0	0	0
		WET					
		CUT (AIR)*	0	50	0	0	0
		TRACOR					
		AIR	.0031	38	0	0	0

* CUT = HYDROPHONE CABLE CUT OFF, SAME PHYSICAL CONDITION AS RECEIVED AT TRACOR